

**DESCRIPTION OF IMMATURE STAGES OF *TRUPANEA IMPERFECTA*
(COQUILLET) (DIPTERA: TEPHRITIDAE)**

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Abstract.—The egg, first-, second- and third-instar larvae, and puparium of *Trupanea imperfecta* (Coquillett), a monophagous, bi- or trivoltine tephritid principally reproducing in flower heads of *Bebbia juncea* (Bentham) Greene (Asteraceae) in southern California, are described and figured for the first time. The egg pedicel is composed mainly of a single row of large aeropyles. As with the other *Trupanea* species previously studied, the lateral spiracular complex of the third instar is unique to *T. imperfecta*, with a stalex sensillum and two verruciform sensilla on the metathorax, and two verruciform sensilla on the abdominal segments. The third instar of *T. imperfecta* very closely resembles *T. arizonensis* Malloch in general habitus and sensory structures.

Key Words: Insecta, *Trupanea*, Asteraceae, nonfrugivorous Tephritidae, taxonomy of immature stages, egg, larva, puparium

The life history of *Trupanea imperfecta* (Coquillett) (Diptera: Tephritidae) was described by Goeden (1988) before adoption of our current format incorporating description of the immature stages. To correct this deficiency and allow full comparison with the 36 species of southern California nonfrugivorous fruit flies for which life histories and descriptions of the immature stages have now been published, this paper describes the immature stages of *T. imperfecta*.

MATERIALS AND METHODS

One-liter samples of excised, immature and mature flower heads from the main host of *T. imperfecta*, *Bebbia juncea* (Bentham) Greene (Asteraceae), potentially containing eggs, larvae, and puparia were transported in cold-chests in an air-conditioned vehicle to the laboratory and stored under refrigeration for subsequent dissection, photography, description, and measurement.

Twenty-two eggs, 23 first-, 14 second-, and nine third-instar larvae, and nine puparia dissected from flower heads were preserved in 70% EtOH for scanning electron microscopy (SEM). Specimens for SEM were hydrated to distilled water in a decreasing series of acidulated EtOH. They were osmicated for 24 h, dehydrated through an increasing series of acidulated EtOH and two, 1-h immersions in Hexamethyldisilazane (HMDS), mounted on stubs, sputter-coated with a gold-palladium alloy, and studied with a Philips XL30-FEG SEM in the Institute of Geophysics and Planetary Physics, University of California, Riverside.

Plant names used in this paper follow Munz (1974); tephritid names follow Foote et al. (1993). Terminology and telegraphic format used to describe the immature stages follow Knio et al. (1996), Goeden and Teerink (1997, 1998, 1999), Goeden et al. (1998a, b), and Teerink and Goeden (1998), and our earlier works cited therein. Means

\pm SE are used throughout this paper. Voucher specimens of *T. imperfecta* eggs, larvae and puparia are stored in a collection of immature Tephritidae acquired by JAT and now maintained by RDG.

RESULTS AND DISCUSSION

Taxonomy

Immature stages.—The egg and puparium of *T. imperfecta* were described and photographs of these stages and larvae were provided by Goeden (1988), but detailed descriptions based on scanning electron microscopy heretofore have not been published.

Egg: The egg (Fig. 1A) of *T. imperfecta* has a short pedicel circumscribed by a single row of subrectangular aeropyles so large that they uniquely occupy more than half of this structure (Fig. 1B). The micropyle is located on the anterior end of the pedicel (Fig. 1C-1).

First instar: White, elongate-cylindrical, rounded anteriorly and posteriorly, minute acanthae circumscribe intersegmental lines (Fig. 2A); gnathocephalon smooth, lacking rugose pads (Fig. 2C); dorsal sensory organ a dome-shaped papilla (Fig. 2B-1); subdorsal sensillum located laterad of dorsal sensory organ (Fig. 2B-2); anterior sensory lobe bears terminal sensory organ (Fig. 2B-3), lateral sensory organ (Fig. 2B-4) and supralateral sensory organ (Fig. 2B-5); stomal sense organ ventrad of anterior sensory lobe (Fig. 2C-1); mouth hooks bidentate (Fig. 2C-2); median oral lobe laterally flattened (Fig. 2C-3); a pair of integumental petals dorsad of mouth hooks (Fig. 2C-4); pit sensillum laterad of mouth lumen (Fig. 2C-5); minute acanthae ventrad of mouth lumen (Fig. 2C-6); anterior spiracle absent; abdominal lateral spiracular complex consists of a spiracle and two verruciform sensilla; caudal segment with two stelix sensilla dorsad and ventrad of posterior spiracular plates (Fig. 2D-1); two verruciform sensilla dorsolaterad of posterior spiracular plates (Fig. 2D-2); posterior spiracular plate

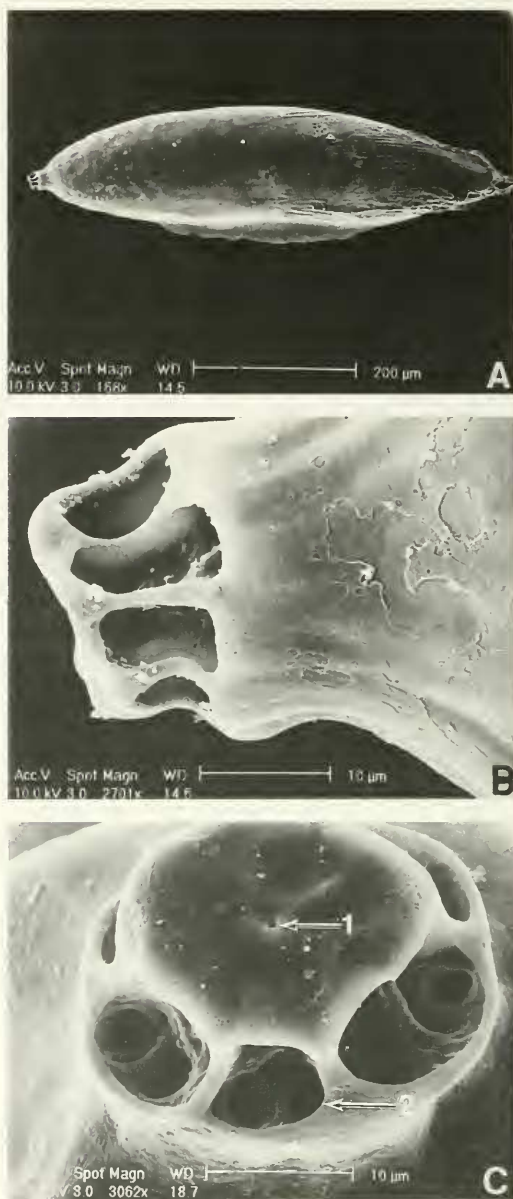


Fig. 1. Egg of *Trupanea imperfecta*: (A) habitus, pedicel to left; (B) egg pedicel; (C) pedicel, anterior view, 1—micropyle, 2—aeopyle.

bears two ovoid rimae, ca. 0.008 mm in length (Fig. 2D-3), and four interspiracular processes, each with 1–3 branches, longest measuring 0.010 mm (Fig. 2D-4); intermediate sensory complex consists of a stelix sensillum (Fig. 2D-5) and a medusoid sensillum (Fig. 2D-6).

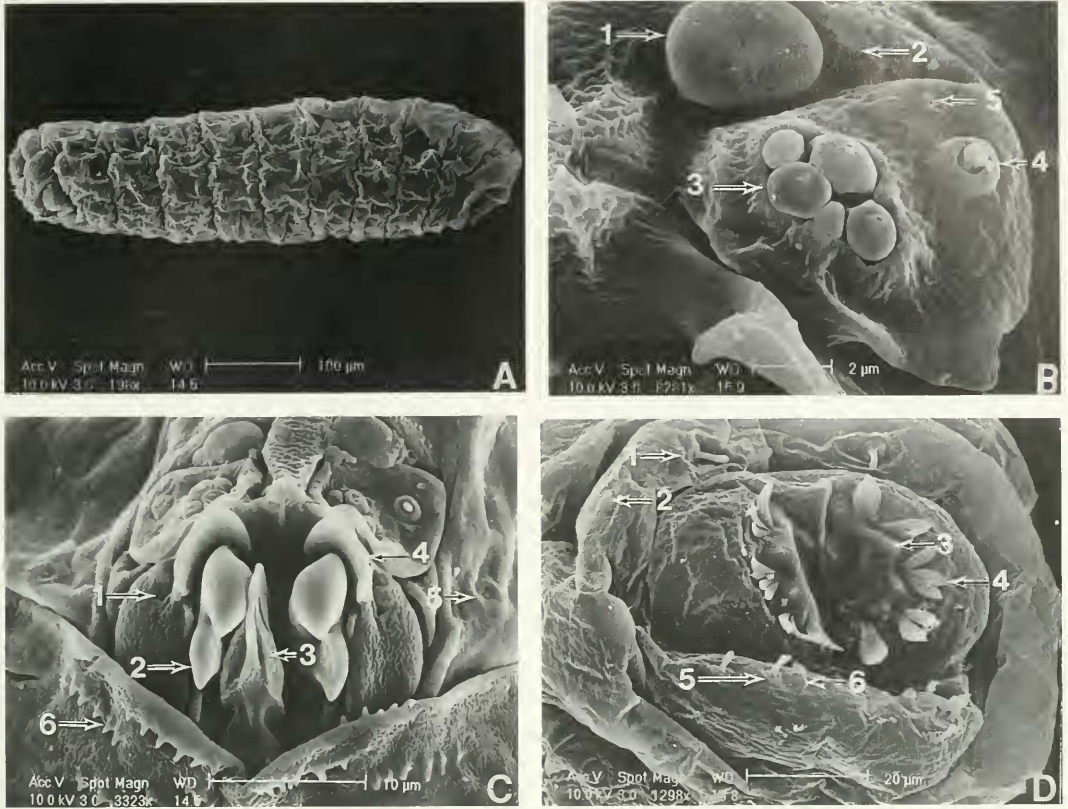


Fig. 2. First instar of *Tripanea imperfecta*: (A) habitus, anterior end to right; (B) anterior sensory lobe, 1—dorsal sensory organ, 2—subdorsal sensillum, 3—terminal sensory organ, 4—lateral sensory organ, 5—supralateral sensory organ; (C) gnathocephalon, anterior view, 1—stomal sense organ, 2—mouth hook, 3—median oral lobe, 4—integumental petal, 5—pit sensillum, 6—minute acanthae; (D) caudal segment, 1—stelex sensillum, 2—verruciform sensillum, 3—rima, 4—interspiracular process, 5—intermediate sensory complex, stelex sensillum, 6—intermediate sensory complex, medusoid sensillum.

Second instar: White, elongate-cylindrical, tapering anteriorly, rounded posteriorly, minute acanthae circumscribe intersegmental lines (Fig. 3A); gnathocephalon conical; rugose pads laterad of anterior sensory lobe (Fig. 3B-1); dorsal sensory organ a dome-shaped papilla (Fig. 3B-2, 3C-1); anterior sensory lobe bears terminal sensory organ (Fig. 3C-2), pit sensory organ (Fig. 3C-3), lateral sensory organ (Fig. 3C-4), and supralateral sensory organ (Fig. 3C-5); stomal sense organ ventrolaterad of anterior sensory lobe (Fig. 3B-3, 3C-6); mouth hooks bidentate (Fig. 3D-1); median oral lobe laterally flattened (Fig. 3D-2); labial lobe attached to median oral lobe (Fig. 3D-3); six pit sensilla circumscribe gnathocephalon

(Fig. 3B-4); minute acanthae circumscribe anterior margin of prothorax (Fig. 3E-1); rugose pads (Fig. 3E-2) and two rows of verruciform sensilla circumscribe prothorax (Fig. 3E-3); anterior thoracic spiracles bear 3 rounded papillae (Fig. 3E-4); lateral spiracular complex not seen; caudal segment with minute acanthae dorsally (Fig. 3F-1); two stelex sensilla dorsad and ventrad of posterior spiracular plates (Fig. 3F-2); two verruciform sensilla dorsolaterad of posterior spiracular plates (Fig. 3F-3); posterior spiracular plate bears three ovoid rimae, ca. 0.021 mm in length (Fig. 3F-4), and four interspiracular processes, each with 1–2 branches, longest measuring 0.013 mm (Fig. 3F-5); intermediate sensory complex

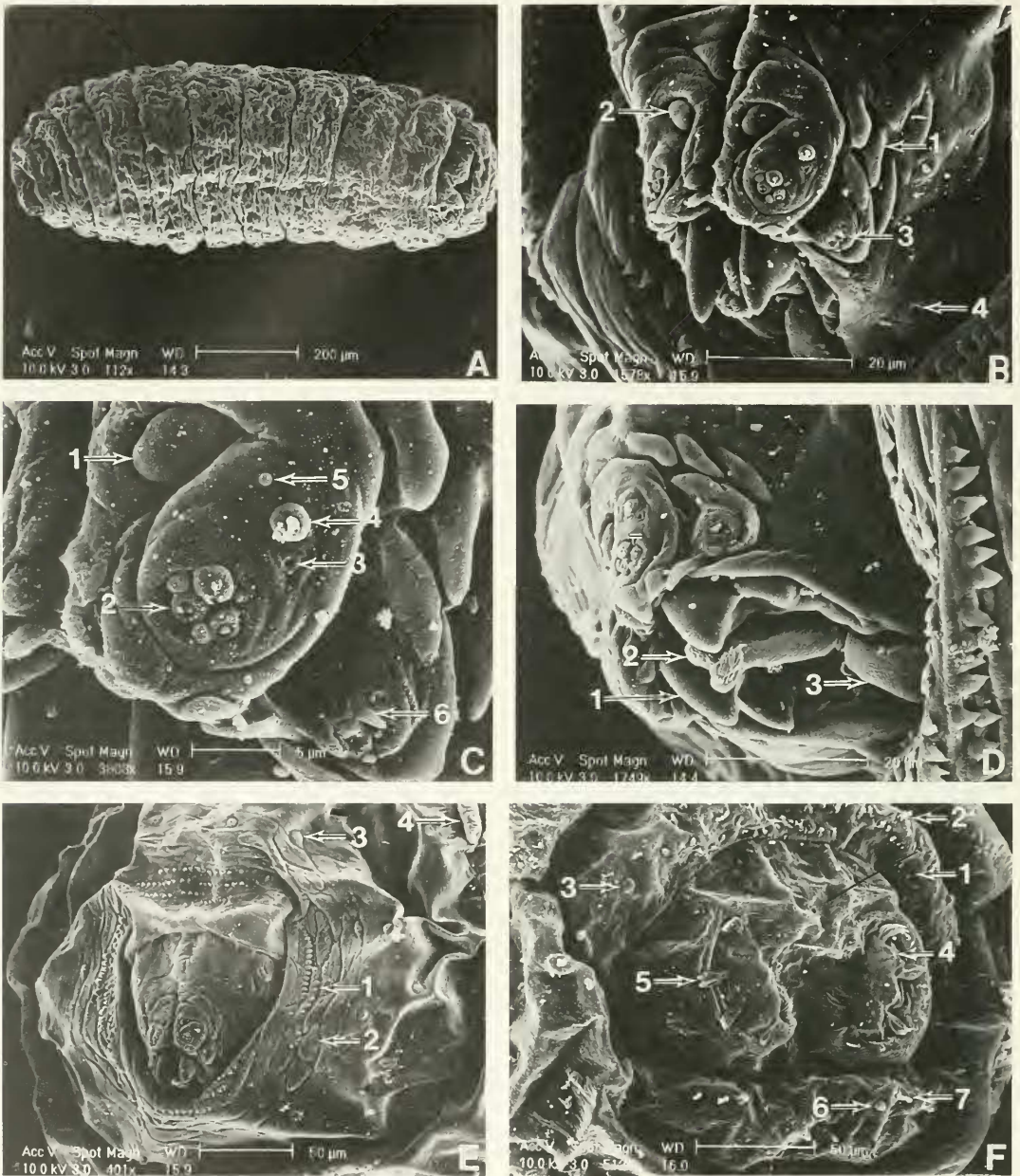


Fig. 3. Second instar of *Trupanea imperfecta*: (A) habitus, anterior view; (B) gnathocephalon, anterior view, 1—rugose pad, 2—dorsal sensory organ, 3—stomal sense organ, 4—pit sensillum; (C) anterior sensory lobe, 1—dorsal sensory organ, 2—terminal sensory organ, 3—pit sensory organ, 4—lateral sensory organ, 5—supralateral sensory organ, 6—stomal sense organ; (D) gnathocephalon, ventral view, 1—mouth hooks, 2—median oral lobe, 3—labial lobe; (E) gnathocephalon, prothorax, anterolateral view, 1—minute acanthae, 2—rugose pads, 3—verruciform sensillum, 4—anterior thoracic spiracle; (F) caudal segment, 1—minute acanthae, 2—stelex sensillum, 3—verruciform sensillum, 4—rima, 5—interspiracular process, 6—intermediate sensory complex, medusoid sensillum, 7—intermediate sensory complex, stelex sensillum.

consisting of a medusoid sensillum (Fig. 3F-6) and a stelex sensillum (Fig. 3F-7).

Third instar: White, elongate-cylindrical, tapering anteriorly, rounded posteriorly, minute acanthae circumscribe intersegmental lines (Fig. 4A); gnathocephalon conical (Fig. 4B), rugose pads laterad of anterior sensory lobe (Fig. 4B-1), those laterad of mouth lumen serrated on ventral margin (Fig. 4C-1); dorsal sensory organ a dome-shaped papilla (Fig. 4B-2, 4C-2); subdorsal sensillum laterad of dorsal sensory organ; anterior sensory lobe (Fig. 4B-3, 4C) bears terminal sensory organ (Fig. 4C-3), pit sensory organ (Fig. 4C-4), lateral sensory organ (Fig. 4C-5), and supralateral sensory organ (Fig. 4C-6); stomal sense organ ventrolaterad of anterior sensory lobe (Fig. 4B-4, 4C-7); mouth hooks tridentate (Fig. 4B-5); median oral lobe laterally flattened, tapering anteriorly (Fig. 4B-6); prothorax circumscribed anteriorly with minute acanthae (Fig. 4D-1); rugose pads circumscribe prothorax posteriorad to minute acanthae (Fig. 4D-2); two rows of verruciform sensilla circumscribe prothorax posteriorad to rugose pads (Fig. 4D-3); stelex sensillum located dorsomedially (Fig. 4D-4); anterior thoracic spiracle bears three rounded papillae (Fig. 4D-5); mesothorax and metathorax circumscribed anteriorly with verruciform sensilla; metathoracic lateral spiracular complex consists of a spiracle (Fig. 4E-1), a stelex sensillum (Fig. 4E-2), and two verruciform sensilla (Fig. 4E-3); abdominal lateral spiracular complex consists of a spiracle (Fig. 4F-1) and two verruciform sensilla (Fig. 4F-2); caudal segment circumscribed by minute acanthae; two stelex sensilla dorsad and ventrad of posterior spiracular plates (Fig. 4G-1); two verruciform sensilla dorsolaterad of posterior spiracular plates (Fig. 4G-2); posterior spiracular plate bears three ovoid rimae, ca. 0.03 mm in length (Fig. 4G-3), and four interspiracular processes, each with 2–4 branches, longest measuring 0.02 mm (Fig. 4G-4); intermediate sensory complex consists of a medusoid sensillum

(Fig. 4H-1), and a stelex sensillum (Fig. 4H-2).

Puparium: Black, elongate-cylindrical (Fig. 5A); anterior end bears the invagination scar (Fig. 5B-1), and anterior spiracles (Fig. 5B-2); caudal segment circumscribed by minute acanthae (Fig. 5C-1), two stelex sensilla dorsad and ventrad of posterior spiracular plates (Fig. 5C-2); two verruciform sensilla dorsolaterad of posterior spiracular plates (Fig. 5C-3); posterior spiracular plate bears three ovoid rimae (Fig. 5C-4), and four interspiracular processes, each with 2–4 branches (Fig. 5C-5); intermediate sensory complex consists of a medusoid sensillum and a stelex sensillum (Fig. 5C-6).

Discussion

The egg of *Trupanea imperfecta* is elongate-ellipsoidal, with a reduced peg-like anterior pedicel (Goeden 1988). It is similar in size and shape to *T. signata* Foote (Goeden and Teerink 1997), longer than *T. actinobola* (Loew) (Goeden et al. 1998b), *T. californica* Malloch (Headrick and Goeden 1991), and *T. pseudovicina* Hering (Goeden and Teerink 1998), and shorter but wider than *T. arizonensis* (Goeden and Teerink 1999). The pedicel is mainly composed of large aeropyles (Figure 1B, 1C). The pedicels of *T. arizonensis*, *T. jonesi* Curran, *T. nigricornis* (Coquillett), and *T. pseudovicina* are similar in shape, but have smaller aeropyles spaced farther apart (Goeden and Teerink 1998, 1999; Goeden et al. 1998a; Knio et al. 1996).

The first instar of *T. imperfecta* is similar in general habitus to previously studied *Trupanea* species (Goeden and Teerink 1998, 1999; Goeden et al. 1998a, b; Knio et al. 1996; Teerink and Goeden 1998). The gnathocephalon is smooth, lacking rugose pads. The pit sensory organ is indistinct on the anterior sensory lobe, and the stomal sense organ is also indistinct. Minute acanthae are limited to the ventral margin of the prothorax. The interspiracular processes, each with 1–3 blade-like processes, are similar to *T. actinobola*, *T. bisetosa* (Coquil-

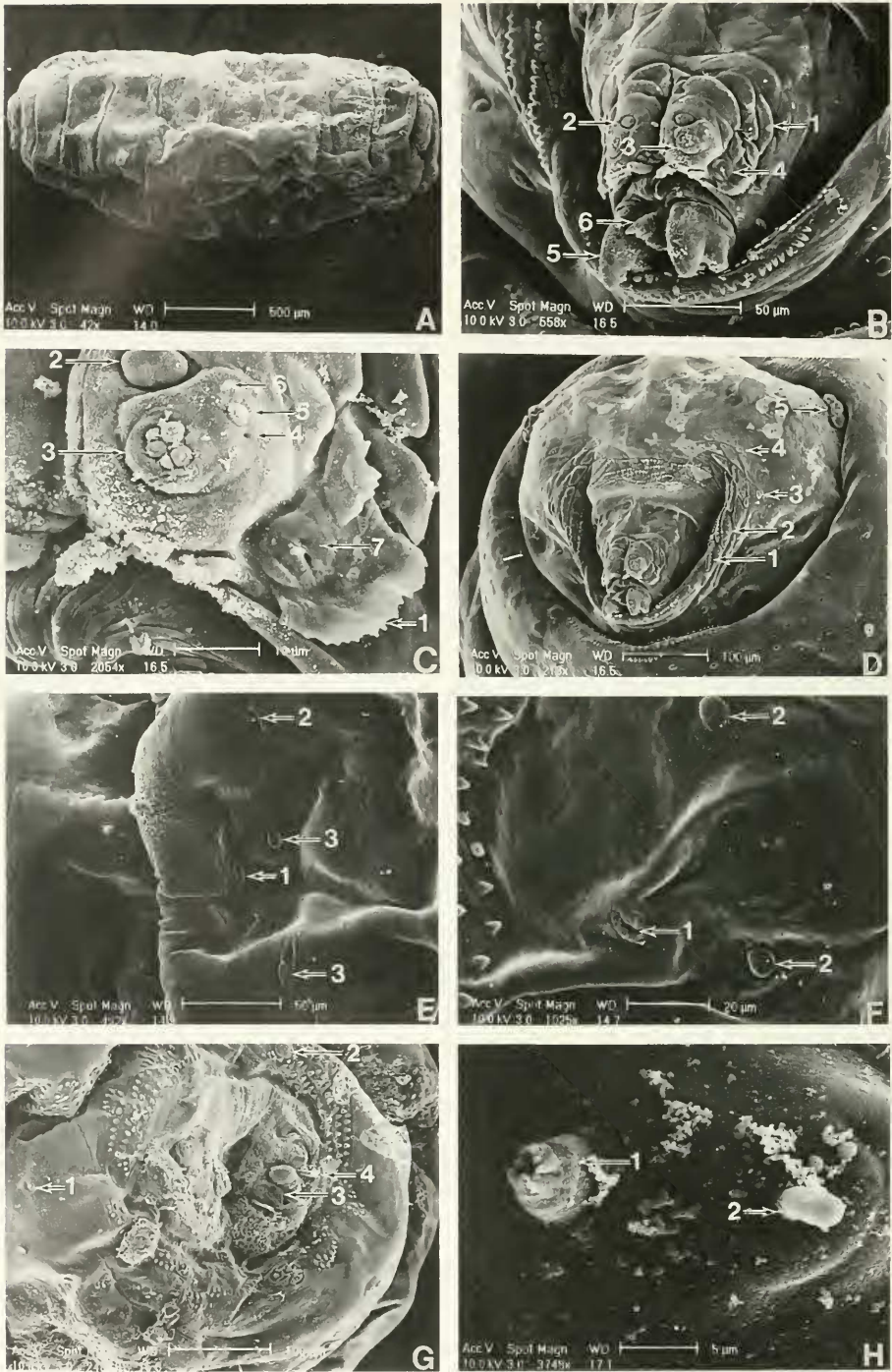


Fig. 4. Third instar of *Trupanea imperfecta*: (A) habitus, anterior to left; (B) gnathocephalon, anterior view, 1—rugose pads, 2—dorsal sensory organ, 3—anterior sensory lobe, 4—stomal sense organ, 5—mouth hook, 6—median oral lobe; (C) anterior sensory lobe, 1—serrated rugose pad, 2—dorsal sensory organ, 3—terminal sensory organ, 4—pit sensory organ, 5—lateral sensory organ, 6—supralateral sensory organ, 7—stomal sense organ; (D) gnathocephalon, prothorax, anterior view, 1—minute acanthae, 2—rugose pad, 3—verruciform sensillum, 4—stelex sensillum, 5—anterior thoracic spiracle; (E) metathorax, 1—spiracle, 2—stelex

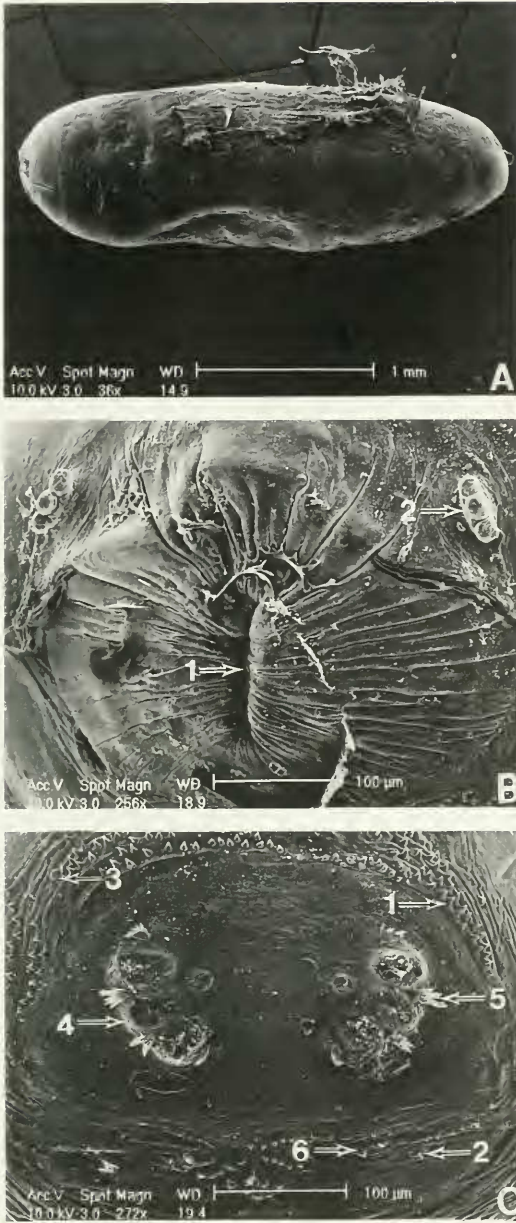


Fig. 5. Puparium of *Trupanea imperfecta*: (A) habitus, anterior end to left; (B) anterior end, 1—invagination scar, 2—anterior thoracic spiracle; (C) caudal segment, 1—minute acanthae, 2—stelix sensillum, 3—verruciform sensillum, 4—rima, 5—interspiracular process, 6—intermediate sensory complex.

lett), and *T. pseudovicina* (Goeden and Teerink 1998; Goeden et al. 1998b; Knio et al. 1996).

The second instar of *T. imperfecta* differs from the first instar in possessing rugose pads laterad of the mouth lumen, and the anterior margin of the prothorax is circumscribed by minute acanthae, rugose pads, and two rows of verruciform sensilla. All four of the anterior sensory lobe sensilla, as well as the stomal sense organ, are distinct in the second instar. The anterior thoracic spiracle is present in the second instar, and the posterior spiracular plates possess three ovoid rimae rather than two as in the first instar. The caudal segment in the second instar, unlike in the first instar, is circumscribed by minute acanthae.

The third instar differs from the second instar in possessing serrated rugose pads laterad of the mouth lumen, and the mouth hooks tridentate. The third instar of *T. imperfecta* is very similar in general habitus to *T. arizonensis* and *T. pseudovicina*, being more elongate-cylindrical than barrel-shaped (Goeden and Teerink 1998, 1999). *Trupanea imperfecta* and *T. arizonensis* are also similar, in that the meso- and metathorax are circumscribed by verruciform sensilla and the anterior thoracic spiracle bears three ovoid papillae (Goeden and Teerink 1998). However, there are slight differences between these two species in that the rugose pads laterad of the mouth lumen are serrated in *T. imperfecta*, but not in *T. arizonensis*. Moreover, the metathoracic lateral spiracular complex is slightly different, with a stelix sensillum and two verruciform sensilla in *T. imperfecta*, and three verruciform sensilla in *T. arizonensis* (Goeden and Teerink 1999). *Trupanea pseudovicina* is similar to *T. imperfecta* in having serrated rugose pads laterad of the mouth lumen (Goe-

sensillum, 3—verruciform sensilla; (F) sixth abdominal segment, 1—spiracle, 2—verruciform sensilla; (G) caudal segment, 1—stelix sensillum, 2—verruciform sensillum, 3—rima, 4—interspiracular process; (H) intermediate sensory complex, 1—medusoid sensillum, 2—stelix sensillum.

den and Teerink 1998). It differs from *T. imperfecta* by having four, not three, papillae on the anterior spiracle; the meso- and metathorax not circumscribed by verruciform sensilla, and a stlex sensillum and two, not one, verruciform sensilla in the metathoracic lateral spiracular complex (Goeden and Teerink 1998). As with the other *Trupanea* species studied by us to date, the lateral spiracular complex is unique to *T. imperfecta* (Goeden and Teerink 1997, 1998, 1999; Goeden et al. 1998a, b; Headrick and Goeden 1991; Knio et al. 1996, Teerink and Goeden 1997).

The puparium of *T. imperfecta* is larger than *T. actinobola* and *T. californica* (Goeden et al. 1998b; Headrick and Goeden 1991), wider but shorter than *T. arizonensis* and *T. pseudovicina* (Goeden and Teerink 1998, 1999).

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